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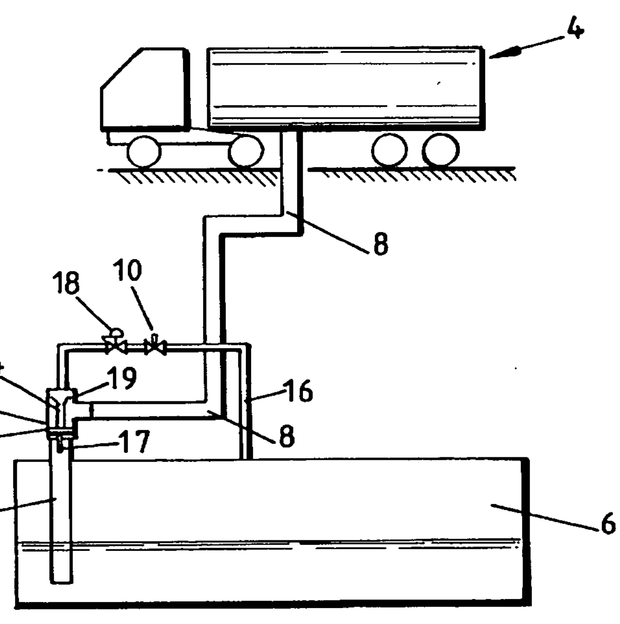
(54) **Title:** PROCESS AND SYSTEM FOR THE RECOVERY OF VAPOUR



(57) **Abstract:** A process and system for the recovery of vapour from a vessel holding a volatile liquid. The delivery of liquid to a vessel (6) iscarried out such that at least one zone of negative pressure is created by the movement of the liquid whereby any vapour in the vessel is drawn into the liquid and returned to the vessel therein.The process and system is particularly suitable for recovering vapours from a tank as fuel is delivered to the tank.

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PROCESS AND SYSTHEM FOR THE RECOVERY OF VAPOUR

DESCRIPTION

The present invention relates to a process for the recovery of vapour from a volatile substance and to a vapour recovery system, particularly but not exclusively for the recovery of vapours from fuel tanks.

Generally, solvent recovery in industrial environments has required the use of an electrical power supply to provide a hot or cold heat source. A hot source has to be protected from the flammable solvents to eliminate the possibility of ignition of the solvent. Additionally, such systems require extensive pipework for transportation of cooling water and difficulties often arise with the pumping of liquids to high levels, such as in vent stacks.

The supply of fuel, such as petrol to storage tanks at filling stations is one instance when a large amount of the substance may be lost as waste vapour. Vapour that is left in an "empty" petrol storage tank is fed back into the supply tank during re-filling of the tank. This is undesirable, particularly if the filling station is owned by a different company to the petrol supply tank since the station owner is paying for the petrol supplied but giving the supplier a tank full of vapour free of charge which may be condensed and re-sold. Additionally, an increase in vapour in a tank leads to a build up of pressure which is clearly undesirable.

Similarly, the filling up of a vehicle fuel tank also results in vapour from the tank being lost to the atmosphere or returning to the supply tank. This is not only economically undesirable but is also environmentally unfriendly.

It is an object of the present invention to provide an improved process for recovery of vapour from a volatile substance that aims to overcome, or at least alleviate, the abovementioned drawbacks.

A further object of the present invention is to provide a system for the recovery of a vapour from a volatile substance that aims to overcome, or at least alleviate, the above-mentioned drawbacks.

Accordingly, a first aspect of the present invention provides a process for the recovery of vapour from a vessel holding a volatile liquid, the process comprising the steps of delivering the liquid to a vessel and creating at least one zone of negative pressure due to movement of said liquid whereby any vapour in the vessel is drawn into the liquid and returned to the vessel therein.

A second aspect of the present invention provides a vapour recovery system for the recovery of vapour from a vessel holding a volatile liquid, the system comprising a delivery conduit for delivering liquid to a vessel and means for creating at least one zone of negative pressure by movement of said liquid whereby any vapour in the vessel is drawn into the liquid and returned to the vessel therein.

The liquid may be delivered to the vessel under the influence of gravity or by pumping means.

Preferably, the movement of the liquid to create a zone of negative pressure is imparted by diverting means. For example, the diverting means may be an angled member that extends obliquely to the normal flow of the fluid. More than one angled member may be provided. Preferably, the delivery pipe that delivers liquid to the tank is provided with an adapter that has the means for diverting the flow of liquid. Alternatively, the diverting means may be formed integrally with the delivery pipe. Preferably, the means is such as to impart a swirling motion in the liquid flow thereby setting up a coriolis effect. In this manner, a partial vacuum is created in the vicinity of the liquid that draws in vapour to result in the vapour being returned to the vessel in the liquid.

The adapter may be in the form of a cylindrical chamber that has means for attachment of the delivery pipe thereto and has means for attachment of a second pipe to deliver the liquid from the adapter to the vessel. Preferably, the chamber is provided with an inwardly extending rim around the perimeter thereof which is angled to constrict the flow of liquid that passes therethrough. Preferably the rim is at an angle of between 10° and 50°. More preferably, the chamber is also provided with one or more members, for example in the form of blades, that extend obliquely across at least a portion of the interior of the chamber. More preferably, three members are provided, preferably extending from the centre of the chamber to the perimeter thereof. Preferably, the members are angled at 10° to 40°.

Alternatively, the chamber may be constructed such that it has a narrowing therein whereby the flow of fluid therethrough is restricted and then expands

following exit from the narrowing, for example by the provision of a chamber that has converging and then diverging sides. The provision of an expansion point also assists in cooling of the fluid.

The chamber is preferably provided with a hollow bar or rod therethrough that extends past the top and base of the chamber. The top of the bar is preferably connected to a supplementary pipe that is in fluid communication with the vessel and the base of the bar preferably extends into the second delivery pipe. In this manner the negative pressure that is set up by the movement of the liquid that is caused by the diverting means provided in the chamber extends up the bar thereby creating a partial vacuum therein to draw any vapour in the vessel along the supplementary pipe and down the bar to be diluted in the liquid and returned to the vessel.

It is to be appreciated that the angled members and hollow bar may be separate components that may be installed in the chamber or the chamber may have these features as an integral part thereof. Additionally, adequate seals should be provided where required to ensure sufficient retention of the negative pressure.

Preferably, the supplementary pipe is provided with a control valve that allows vapour to enter the pipe once a predetermined pressure is reached. An expansion valve may also be provided to have a cooling effect on the vapour and the contents of the vessel.

More preferably, a control valve is provided within the chamber and is activated by the flow of fluid through the chamber. Preferably, movement of the valve is assisted by the provision of a piston balance.

It is to be appreciated that if an expansion point is provided within the chamber, an expansion valve would not be required.

The process and system referred to above are particularly suitable for use in relation to a fuel delivery system that delivers fuel, such as petrol, from a fuel supply tanker to a storage tank.

In an alternative embodiment of the present invention, means may be provided to create a zone of negative pressure as liquid enters a vessel by means of a fluid dispensing nozzle. For example, in relation to the delivery of fuel to a vehicle tank. Preferably, the nozzle is provided with diverting means and at least one aperture through the side of the nozzle in the region of the diverting means for drawing vapour into the nozzle by means of the negative pressure created by the flow of liquid around the diverting means.

To this end, a third aspect of the present invention provides a liquid dispensing nozzle for the delivery of liquid to a vessel, the nozzle comprising a conduit having means for creating at least one zone of negative pressure due to the movement of liquid therethrough and at least one aperture in the region that the negative pressure is created.

The delivery pipe that delivers liquid into the vessel may be provided with an adapter having means for diverting and/or constricting the flow of the liquid.

Preferably, the adapter is in the form of a flow-diverting bush that affects the movement of the liquid in such a manner as to create a zone of negative pressure which causes any vapour in the vessel to be drawn into the flow of liquid and returned to the vessel. For example, the bush may divert the flow to create a liquid screen that has a zone of negative pressure associated therewith to pull any vapour into the liquid. Preferably, the flow-diverting bush is provided with at least one angled surface. Preferably, the angled surface is 10° to 30°.

Preferably, the flow-diverting bush has an inner tube at least partially surrounded with a sleeve. Preferably, the bush has a first section, middle section and a third section. The sleeve preferably surrounds the middle section of the bush. More preferably, the first section is provided with grooves that form subsidiary channels around the periphery of the inner tube. The sleeve preferably has an angled flange that obstructs the flow of liquid that travels along the subsidiary channels thereby deflecting the liquid.

Preferably, the end of the inner tube forming the third section of the bush is provided with a chamfered edge thereby constricting the flow of liquid that passes from the inner tube. This end of the tube is preferably attached to a pipe that is provided with a series of holes that are substantially in line with the chamfered area of the inner tube.

In this manner, the angled flange of the sleeve and the chamfered edge of the inner tube disturb the normal flow of the liquid to create zones of negative

pressure that pull any vapour into the liquid and thereby return the vapour to the vessel.

Alternatively, the end of the nozzle itself may constructed to create a zone of negative pressure as fluid is passed through the nozzle. For example, the tube of the nozzle may be chamfered or profiled, for example by means of a throat valve, to direct the flow of fluid into a further narrowing provided in the nozzle. The further narrowing is preferably surrounded by a sleeve or sheaf and apertures are provided through the sleeve and wall of the narrowing whereby vapour can be drawn into the flow of fluid.

Preferably, the nozzle is provided with a skirt that may form a seal around the opening of the vessel to prevent the escape of vapour therefrom. More preferably, at least part of the nozzle is surrounded by insulating means to prevent heat ingress into the nozzle.

The system and process of the present invention may be used in conjunction with a further system and method for the recovery of vapour from a vessel holding a volatile liquid. For example, cool gas, such as nitrogen, may be supplied to a heat exchanger provided in the vessel or a vent stack to cool the vapour thereby assisting in its return to the vessel and reducing the pressure build up in the vessel. Preferably, the cool gas is provided by a vortex generator.

A vapour recovery system according to the present invention may be provided in any other part of a system that delivers volatile substances to a vessel, such as a drop tube that delivers fluid to a storage tank or in a vehicle cap filler.

The aforementioned parts are constructed such as to create a zone of negative pressure as the fluid passes therethrough thereby drawing vapour into the path of the fluid.

For a better understanding of the present invention and to show more clearly how it may be carried into effect, reference will now be made by way of example only to the accompanying drawings in which:-

Figure 1 is a schematic diagram of a petrol tanker and storage tank having a vapour recovery system according to one embodiment of the present invention;

Figure 2 is a schematic diagram of the vapour recovery system shown in Figure 1;

Figure 3 is perspective view of the swirl-imparting chamber of the vapour recovery system shown in Figures 1 and 2;

Figure 4 is a perspective view of a component of the swirl-imparting chamber shown in Figure 3;

Figure 5 is a perspective view of a pipette for attachment to the swirl-imparting chamber shown in Figure 3, together with fixing means therefor;

Figure 6 is a longitudinal sectional view of an alternative pipette for attachment to the swirl-imparting chamber;

Figure 7 is a cross-sectional view of the upper section of a swirl-imparting chamber:

Figure 8 is a schematic diagram of a petrol tanker and storage tank having a vapour recovery system according to the present invention in conjunction with a supplemental vapour recovery system;

Figure 9 is a schematic diagram of a storage tank having a vapour recovery system according to a second embodiment of the present invention;

Figure 10a is a schematic cross-sectional diagram of the chamber of the vapour recovery system shown in Figure 9;

Figure 10b is a schematic diagram of the individual components making up the chamber shown in Figure 10a;

Figure 10c is a perspective view of the balance piston of the chamber shown in Figure 10a;

Figure 11 is a schematic diagram of a drop tube entering a storage tank, the drop tube being fitted with a vapour recovery system according to a third embodiment of the present invention;

Figure 12 is schematic diagram of a petrol delivery nozzle and vehicle tank having a vapour recovery system according to a fourth embodiment of the present invention;

Figures 13a and 13b illustrate a number of the individual components for the vapour recovery system shown in Figure 12;

Figures 14a and 14b are respectively perspective and cross sectional views of a bush component for the vapour recovery system shown in Figure 12;

Figure 15 illustrates the components shown in Figures 13a to 14b assembled together for incorporation in the vapour recovery system of Figure 12;

Figure 16 is a schematic side view of a petrol delivery nozzle and vehicle tank having a vapour recovery system according to a fifth embodiment of the present invention;

Figure 17 is a schematic diagram illustrating the end view arrangement for the nozzle shown in Figure 16;

Figure 18 is a schematic diagram of a petrol delivery nozzle and vehicle tank having a vapour recovery system according to a sixth embodiment of the present invention; and

Figure 19 is a schematic diagram of a vehicle car filler cap system fitted with a vapour recovery system according to a seventh embodiment of the present invention.

The present invention utilizes the potential energy created by the delivery of a volatile liquid, such as petrol, to a storage tank. The utilization of this energy as the liquid drops down a delivery tube into the storage tank enables a vapour recovery system to be provided that requires no external energy source.

Figures 1 to 7 of the accompanying drawings illustrate one embodiment of a vapour recovery system according to the present invention. Referring in particular to Figures 1 and 2 in the first instance, a petrol tanker 4 supplies petrol to a storage tank 6 at a filling station via a delivery pipe 8. Normally, petrol vapour in the storage tank passes back up to the petrol tanker or is released to the atmosphere via

a vent. However, in the illustrated embodiment, the petrol passes through a swirl-imparting chamber 10 or cage that induces a coriolis effect into the petrol as it is delivered into the tank via a pipe 12. The swirling motion induced in the petrol creates a partial vacuum in the centre thereof that passes up a hollow cylindrical member 14 that is provided through the centre of the swirl-imparting chamber and extends as a pipette 17 from the base of the chamber into the pipe 12.

The hollow member 14 also extends from the top of the chamber 10 to a subsidiary pipe 16 that is in fluid communication with the storage tank 6. The establishment of a partial vacuum in the member causes vapour to be sucked from the tank into the pipe and through the member 14. The vapour is then passed back into the tank via pipette 17 by dilution in the petrol that enters through the pipe 12.

The subsidiary pipe 16 is provided with a control valve 18 and expansion valve 20. The control valve is opened by the presence of a partial vacuum in the hollow member downstream thereto which acts on the diaphragm of the control valve. This allows any vapour from the tank that is drawn up the hollow member to pass through the expansion valve which has a cooling effect on the vapour. This further reduces the vapour pressure in the tank by condensing the vapour and/or assists in cooling the tank. The control valve monitors the pressure such that the vapour recovery system is operation once a predetermined vacuum is achieved in the hollow member. Hence, the accumulative effect of the system is to take vapour from the space at the top of the tank into dilution in the petrol entering the tank

which reduces the pressure in the tank. The cooling effect also reduces the overall effect of the natural aspiration above the tank.

Figures 3 to 7 of the accompanying drawings illustrate the components of the vapour recovery system in further detail. Figure 3 illustrates the swirl-imparting chamber 10 or cage that is a generally cylindrical vessel sealed at both ends and having a side branch 21 that is connected to the main delivery pipe 8. The chamber has a cylindrical hollow member 14 extending through the centre thereof and has a cylindrical base component 22 that is relieved of material to allow petrol to flow therethrough (see Figures 3 and 4). The base component has a central collar 21 for passage of the member 14 and the upper edge of the component is provided with an inwardly extending rim 24, the surface of which is angled, preferably 10° to 50° from the horizontal. Three blades 26 are provided at spaced apart intervals extending from the central collar to the perimeter of the base. The blades are orientated such that their upper surfaces extend obliquely to the path of travel of the petrol, preferably at an angle of 10° to 40°. The petrol contacts these surfaces as it travels through the chamber and the obstruction to its flow imparts a swirling motion to the fluid. The base component is also provided with a circular flange 25 extending from the lower edge thereof for attachment of the pipe 12 that delivers petrol into the tank. The pipette 17 is connected to the base component by a nut 27 and washer 29 or other suitable fastening means, as shown in Figure 5. Alternatively, the pipette 17' may be provided with a shoulder 27' and circlip 29' in

place of the fastening means for retention in the base component, as shown in Figure 6.

It is to be appreciated that the base component, chamber and/or central hollow member may be formed as an integral unit. The angle of the rim and the blades of the base component may be altered, being adjusted to the required angle to ensure a maximum coriolis effect. Less or more than three blades may be provided across the opening of the base component but should be such as to ensure the creation of a sufficient coriolis effect without blocking the flow of petrol to too great an extent.

The diameter of the bore that extends through the hollow cylindrical member of the chamber may be varied in proportion to the height of the drop of the fluid and energy stored, preferably being in the range 3mm to 20mm in diameter. Similarly, the length of the member may be varied to maximize the vacuum within the coriolis area. This will be necessary for varying size of tanks.

It is also important to provide adequate seals between the pipes and the swirl-imparting chamber or cage to ensure that a sufficient vacuum is retained in the system. Figure 7 of the accompanying drawings illustrates one way of providing a tight seal between the delivery pipe and top 19 of the swirl imparting chamber. A plate 23 is provided below the top plate 21 of the chamber and an O-ring 27 is provided between the two plates. The plates are screwed together by retaining screws 25 causing the O-ring 27 to be compressed and form a tight seal.

The components of the system may be made of any suitable material. The swirl-imparting chamber, hollow member and base component are preferably made of metal, with the other pipes being of a composite plastics material.

Figure 8 of the accompanying drawings illustrates how the vapour recovery system according to the present invention may be used in conjunction with another system to provide enhanced vapour recovery. Identical features already described in relation to Figures 1 to 7 are given the same reference numerals and only the differences are described in detail. Vapour from the tank may also pass up a pipe 40 into a vent stack 42. A heat exchanger is provided that has a supply of cool gas, such as air or nitrogen. The supply of cool air or other gas is preferably provided from a vortex generator, such as by means of the system described in the Applicant's co-pending PCT Patent Application No. PCT/GB00/03907. When the pressure in the pipe reaches a predetermined level, the supply of cool gas from the vortex generator is activated such that it is passed through the heat exchanger to cool the vapour and assist in returning the condensed vapour to the tank.

The aforementioned system preferably uses a source of nitrogen as the cool gas for aiding condensation of the vapour. This also allows nitrogen to be introduced as a blanketing gas to the tanks. The use of nitrogen instead of air reduces the amount of oxygen and moisture entering the system thereby making the system safer and minimizing corrosion of the tank. The use of nitrogen as a blanket gas will also result in nitrogen being returned to the tanker. The nitrogen may also

be used for other applications on site that normally use a compressed air supply, such as the inflation of tyres and in car washes.

The system can include compressors 50, air purifying system and storage bottle 52 with relevant regulating equipment 54. The regulator allows nitrogen into the tanks if the pressure drops below a predetermined set pressure, such as + 5 mbar.

Figures 9 to 10c of the accompanying drawings illustrate an alternative vapour recovery system incorporated within a delivery pipe that supplies petrol from a petrol tanker to a storage tank at a filling station. Again, a delivery pipe 8 is attached to a chamber 10' having a hollow cylindrical member 14' passing through the centre thereof that is attached to a further pipe 12 that is in fluid communication with the tank. The hollow member extends from the top of the chamber but terminates within the end part 312 of the chamber 10'. A control valve 180 is provided that is situated in the path of the flow of petrol (indicated by the arrows in Figure 9). Additionally, the end part 312 of the chamber that surrounds the end of the member 14' is bevelled to provide with an area of reduced diameter that then slopes outwardly to provide an expansion point E.

Figures 10a to 10c illustrate the construction of the chamber in further detail. The chamber comprises a venturi tube or pipe 14', a fluid catchment bush 300 attached to a valve cap 180a and body 180b by fastening means 301. The valve body is also provided with a balance piston 302 having an allen cap screw 303, O ring 304 and split pin 305. Return springs 306 act on the piston balance and valve.

The venturi pipe 14' and valve 180 are connected to an adaptor 307 for connection to a subsidiary pipe (not shown) via a bridging piece 308, cage retaining collar 309, split collar 310, cage legs 311 and an adapter piece 314. An end piece 312 is provided at the base of the venturi pipe. This has inwardly tapering sides that then diverge to provide an expansion point E.

Negative pressure formed at the end of the pipe or tube 14' has a direct influence on the underside of the piston balance 302, assisting in operation of the shut-off valve reacting against closing springs 306. The flow of vapour is controlled by a number of holes 316 around the circumference of the piston 302. These holes can be varied in size and number dependent upon flow and requirement on customer site. The object of these adjustments is to tune the unit to suit the height the fluid drops through unit 312 and the expansion point E whilst retaining the differential required to operate the balance piston 302.

In this manner, petrol enters the chamber 10' through the delivery pipe 8 causing closure of the valve 180. As the petrol passes the expansion point E a negative pressure is created that causes a vacuum to develop in the tube 14'. This has the effect of drawing any vapour into the path of the petrol causing it to return with the flow of fluid back to the storage tank.

The embodiment shown in Figures 9 to 10c removes the need for the valves 18, 20 shown in Figures 1, 2 and 8 that are situated exterior to the chamber. Instead, the valve is formed within chamber thereby providing a unit that can be easily and simply fastened onto a delivery pipe. The provision of the valve in this

location enables the valve to be activated in response to a flow of petrol, thereby ensuring that the system is shut off when no fluid is flowing. Additionally, the valve is operated using the energy of the petrol. Furthermore, the provision of an expansion point formed as part of the chamber achieves a cooling of the fluid and vapour without the need for a separate expansion valve.

Figure 11 illustrates a vapour recovery system according to another embodiment of the present invention that may be provided to achieve the same end result as those systems described above but incorporates the vapour recovery system within the drop tube of the underground storage tank rather than the delivery pipe. A region of the drop tube 400 is provided with a series of holes 401 around the circumference thereof and an inner tube 402 is provided within the drop tube in the region of these holes. The inner tube has a restriction or narrowing 403 in a region thereof whereby petrol that flows through the inner tube expands following constriction through the narrow region thereby creating a zone of negative pressure. This in turn causes any vapour V to be drawn in through the holes and return to the storage tank in the petrol.

Figures 12 to 15 of the accompanying drawings illustrate a vapour recovery system according to another embodiment of the present invention. The system is provided to minimize the loss of vapour, such as petrol vapour, from a vehicle tank during filling of the tank at a filling station. Again, potential energy created by the motion of the petrol as it is dropped into the tank is used to form a partial vacuum

or zone of negative pressure that causes vapour to be drawn into the path of the petrol, thereby diluting the vapour and returning it to the vehicle tank.

The vapour recovery system 100 is connected to the fuel dispensing nozzle 102 that is introduced into a fill port 104 of a vehicle in order to deliver fuel to the vehicle fuel tank 106 via a delivery tube 107. A skirt 105 is provided around the end of the dispensing nozzle to form a substantially airtight seal between the nozzle and the fill port.

The vapour recovery system comprises a flow-diverting bush 108 that is connected to the delivery tube and has an inner tube 110 forming a main central channel 111 that extends through the entire length of the bush. The intended outer end of the inner tube is provided with grooves 112 extending around the perimeter thereof that form multiple subsidiary channels. These channels are of a set width and depth, such as 1mm depth and 1mm width. The middle section of the bush is provided with a sleeve 114 that has an angled flange or chamfer 116 at one end thereof that obstructs the path of fluid that flows along the subsidiary channels 112 thereby acting as a deflector to divert flow of the fluid around the outside of the bush. Preferably, the flange is set at an angle between 10° and 30°. The end of the inner tube at the intended inner end of the bush is also provided with a chamfer 119. This diverts the flow of fluid in the main channel inwardly. Pipes 121, 122 are attached to either end of the bush, the pipe 122 that is placed over the chamfered end of the inner tube being provided with a series of holes 118 that are substantially

in line with the chamfered area of the tube. The holes may be, for example, 0.3 to 1mm in diameter.

In this manner, fuel from the dispensing nozzle passes into the bush and a proportion of the fluid is diverted along the subsidiary channels or grooves 112. This fluid is then deflected outwardly as it hits the angled flange 116 of the sleeve 114 and forms a viscous film between the sleeve and pipe that acts a screen 120. The area in front of the screen is at negative pressure (indicated by NP on Figure 12) which causes vapour to be sucked into the path of the fuel by means of a venturi effect and be delivered back to the fuel tank thereby reducing the amount of vapour escaping from the vehicle tank. Additionally, the fuel that passes through the inner tube of bush is constricted due to the presence of the chamfered area 119 at the end of the inner tube. This causes an area of negative pressure on the outer side of the chamfer (indicated by NP on Figure 15). This creates a venturi effect which results in vapour being drawn into the path of the fluid through holes 118. The combined effect is to reduce, or even possibly eliminate, the loss of vapour from a fuel tank.

Figures 16 and 17 illustrate an alternative vapour recovery system according to the present invention that is suitable for a vehicle petrol nozzle and delivery pipe to reduce the loss of petrol vapour during filling of a vehicle petrol tank. The nozzle 500 is provided with a narrowings 502 formed by a profiled throat valve at a point along the length of the tube 501 of the nozzle to restrict the flow of petrol as it passes through the tube. The throat valve 502 is provided at a bend in the tube and causes a slight change in velocity which provides a temperature reduction at

expansion point E. This results in a cooling effect at the point of entry of the dispensing nozzle into the vehicle tank which assists in preventing any loss of vapour that is trying to escape past the nozzle.

Prior to the end of the nozzle there is provided a further narrowing 503, for example in the form of a throat valve, part of which enters an inner tube or sheaf 504. This causes an aerodynamic affect at the gap between the nozzle and the inner tube generating the vacuum source. Holes 505 are provided through the inner tube and the tube 501 in this region. In this manner, fluid is directed into the inner tube provided in the end of the nozzle and then expands as it leaves the end of the nozzle causing a negative pressure to be set up such that any vapour V can be drawn into the flow of fluid through the holes 505 and returned to the tank in the petrol. The expansion points E also effect a reduction in temperature of the fluid and vapour. An insulated sleeve 506 is provided around the end of nozzle to assist in the cooling effect by preventing heat ingress through the nozzle wall. The cooling and condensing effects lower the pressure in the car tank.

Figure 18 illustrates an alternative arrangement within a fuel dispensing nozzle wherein an expansion point E is provided in the nozzle by means of a bevelled surface 601 within the tube 600. At the end of the nozzle, the diameter of the tube is reduced and surrounded by a sleeve 602. Slots and holes 603 are provided through the sleeve and the tube. In this manner, the flow of fluid is restricted as it passes through the inner tube and then expands as it passes from the inner tube to the outer sleeve causing a region of negative pressure to be created.

This causes any vapour V to be drawn in to the inner tube through the slots and holes provided at the end of the nozzle thereby causing the vapour to be returned to the tank in the flow of fluid dispensed by the nozzle. The expansion point E also effects cooling of the fluid.

It is to be appreciated that the vehicle filler cap could be provided with a vapour recovery system according to the present invention instead of, or in addition to, the fuel dispensing nozzle. Figure 19 of the accompanying drawings illustrates an example of a vehicle filler cap 700 fitted with a vapour delivery system according to an embodiment of the present invention. The cap is provided with an inner tube 702 extending from the end that contacts the nozzle N and a gap 704 is provided between the sides of the inner tube and the cap. The inner tube is provided with chamfered sides whereby the diameter of the inner tube decreases in the region of the cap. Holes or slots (not shown) may also be provided through the sides of the inner tube. In this manner, the flow of fluid is constricted and then expands as it passes from the inner tube into the main cap thereby creating a zone of negative pressure that sucks in any vapour from the tank into the flow of fluid through the gap and/or holes.

CLAIMS

1. A vapour recovery system for the recovery of vapour from a vessel holding a volatile liquid, the system comprising a delivery conduit (8) for delivering liquid to the vessel (6) and means for creating at least one zone of negative pressure by movement of said liquid whereby any vapour in the vessel is drawn into the liquid and returned to the vessel therein.

2. A vapour recovery system as claimed in claim 1 wherein diverting means is provided to impart movement in the liquid to create the zone of negative pressure.

3. A vapour recovery system as claimed in claim 2 wherein an angled member (26) is provided that extends obliquely to the normal flow of liquid.

4. A vapour recovery system as claimed in claim 2 or 3 wherein the diverting means is such as to impart a swirling motion in the liquid thereby setting up a coriolis effect to create a partial vacuum in the viscinity of the liquid.

5. A vapour recovery system as claimed in claim 2, 3 or 4 wherein the delivery conduit is provided with a chamber (10) having the diverting means.

6. A vapour recovery system as claimed in claim 5 wherein the chamber (10) is provided with an inwardly extending rim (24) around the periphery thereof that is angled to constrict the flow of liquid that passes therethrough.

7. A vapour recovery system as claimed in claim 5 or claim 6 wherein the chamber has one or more members (26) that extend obliquely to at least a portion of the interior of the chamber.

8. A vapour recovery system as claimed in claim 5 or claim 6 wherein the chamber is provided with a narrowing therein whereby the flow of liquid therethrough is restricted and then expands following its exit from the narrowing thereby creating the zone of negative pressure.

9. A vapour recovery system as claimed in any one of claims 5 to 8 wherein the chamber (10) is provided with a hollow bar or rod (14) therethrough that extends past the top of the chamber whereby the negative pressure created by the flow of fluid extends up the hollow bar or rod.

10. A vapour recovery system as claimed in claim 9 wherein the top of the bar (14) is connected to a supplementary pipe (16) that is in fluid communication with the vessel.

11. A vapour recovery system as claimed in claim 9 or claim 10 wherein the base of the bar extends into a second delivery pipe (12) that delivers liquid to the vessel.

12. A vapour recovery system as claimed in claim 10 or claim 11 wherein the supplementary pipe (16) is provided with a control valve (18) that allows vapour to enter the pipe only once a predetermined pressure is reached.

13. A vapour recovery system as claimed in claim 10, 11 or 12 wherein an expansion valve (20) is provided to have a cooling effect on the vapour and contents of the vessel.

14. A vapour recovery system as claimed in any one of claims 5 to 11 wherein a control valve (180) is provided within the chamber and is activated by the flow of liquid through the chamber.

15. A vapour recovery system as claimed in claim 14 wherein movement of the valve is assisted by the provision of a piston balance (302).

16. The use of a vapour recovery system as claimed in any one of the preceding claims for the delivery of fuel from a fuel supply tanker to a storage tank.

17. A vapour recovery system as claimed in claim 2 wherein the diverting means is provided in a fluid dispensing nozzle (102).

18. A vapour recovery system as claimed in claim 17 wherein the fluid dispensing nozzle (102) is provided with an adapter (100) having means for diverting the flow of liquid.

19. A vapour recovery system as claimed in claim 18 wherein the adapter is in the form of a flow-diverting bush (108) that affects movement of the liquid in such a manner as to create a zone of negative pressure.

20. A vapour recovery system as claimed in claim 19 wherein the flow-diverting bush is provided with at least one angled surface (116,119).

21. A vapour recovery system as claimed in claim 20 wherein the flow-diverting bush (108) is provided with an inner tube (110) at least partially surrounded by a sleeve (114).

22. A vapour recovery system as claimed in claim 21 wherein the sleeve is provided with means (116) to obstruct the flow of liquid through the inner tube.

23. A vapour recovery system as claimed in claim 22 wherein the flow-diverting bush has a first section, a second section and a third section, the first section being provided with grooves that form subsidiary channels (112) around the periphery of the inner tube (110), the sleeve (114) surrounding the middle of the section of the bush and having an angled flange (116) that obstructs the flow of fluid as it travels along the subsidiary channels, thereby deflecting the liquid.

24. A vapour recovery system as claimed in claim 21, claim 22 or claim 23 wherein the end of the inner tube (110) is provided with a chamfered edge (119) thereby constricting the flow of liquid that passes through the inner tube.

25. A vapour recovery system as claimed in claim 24 wherein the end of the inner tube is attached to a pipe (122) that is provided with a series of holes (118) that are substantially in line with the chamfered area (119) of the inner tube.

26. A vapour recovery system as claimed in claim 17 wherein the nozzle (500) itself is constructed to create a zone of negative pressure as fluid is passed through the nozzle.

27. A vapour recovery system as claimed in claim 26 wherein the nozzle is provided with diverting means and at least one aperture through a side of the nozzle for drawing vapour into the nozzle by means of the negative pressure created by the flow of liquid over the diverting means.

28. A vapour recovery system as claimed in claim 27 wherein the tube of the nozzle is provided with a narrowing in a region thereof that is surrounded by a sleeve, the wall of the narrowing and the sleeve having apertures whereby vapour can be drawn into the tube.

29. A vapour recovery system as claimed in any one of claims 17 to 28 wherein the nozzle is provided with a skirt (105) for forming a seal around the opening of the vessel (104).

30. A liquid dispensing nozzle for the delivery of liquid to a vessel, the nozzle (500) comprising a conduit (501) having means (502, 503) for creating at least one zone of negative pressure due to the movement of liquid therethrough and at least one aperture (505) in the region that the negative pressure is created.

31. The use of a vapour recovery system as claimed in claim 1 in a drop tube that delivers liquid to a storage tank.

32. The use of a vapour recovery system as claimed in claim 1 in a vehicle cap filler.

33. A process for the recovery of vapour from a vessel holding a volatile liquid, the process comprising the steps of delivering the liquid to a vessel and creating at least one zone of negative pressure due to movement of said liquid whereby any vapour in the vessel is drawn into the liquid and returned to the vessel therein.

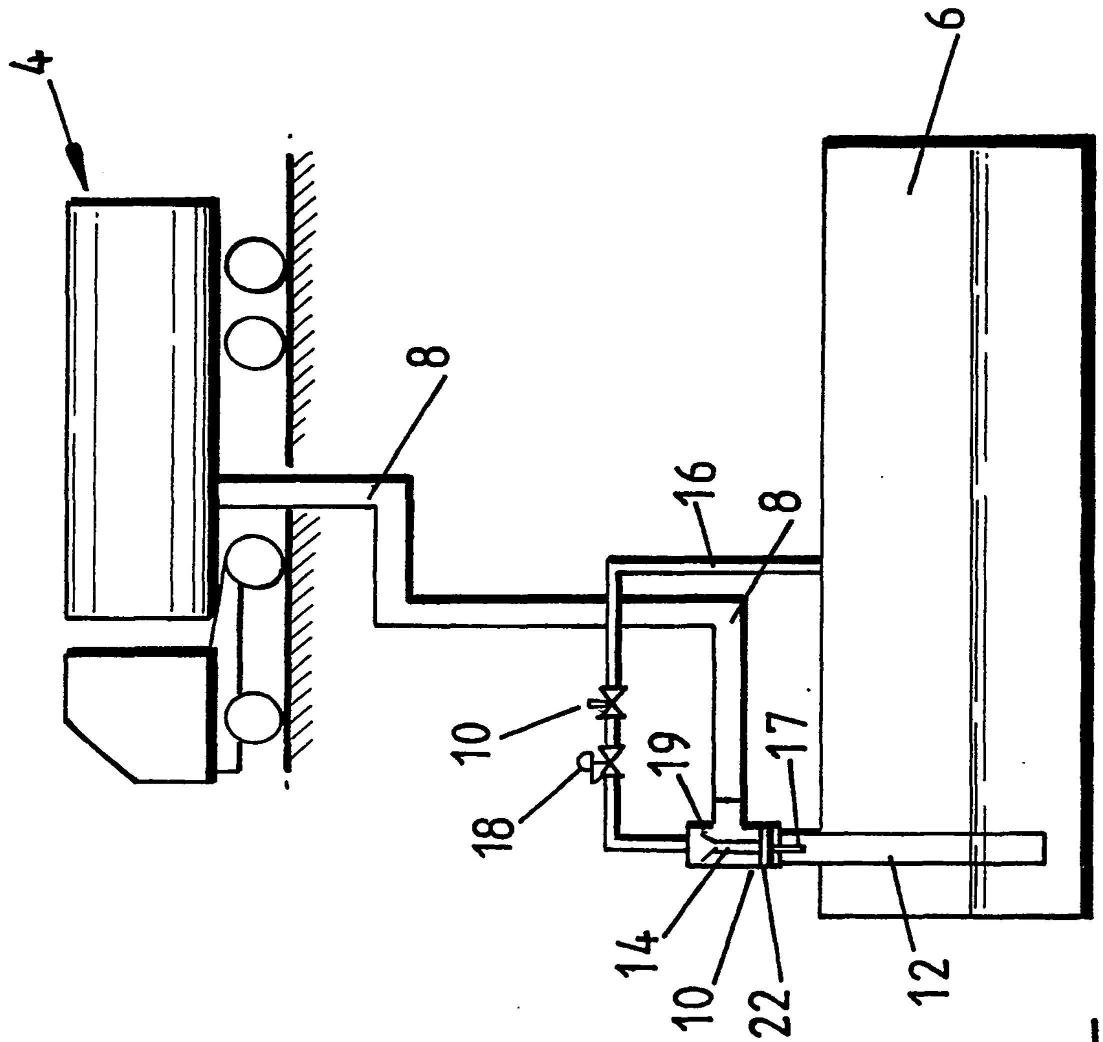

FIG. 1

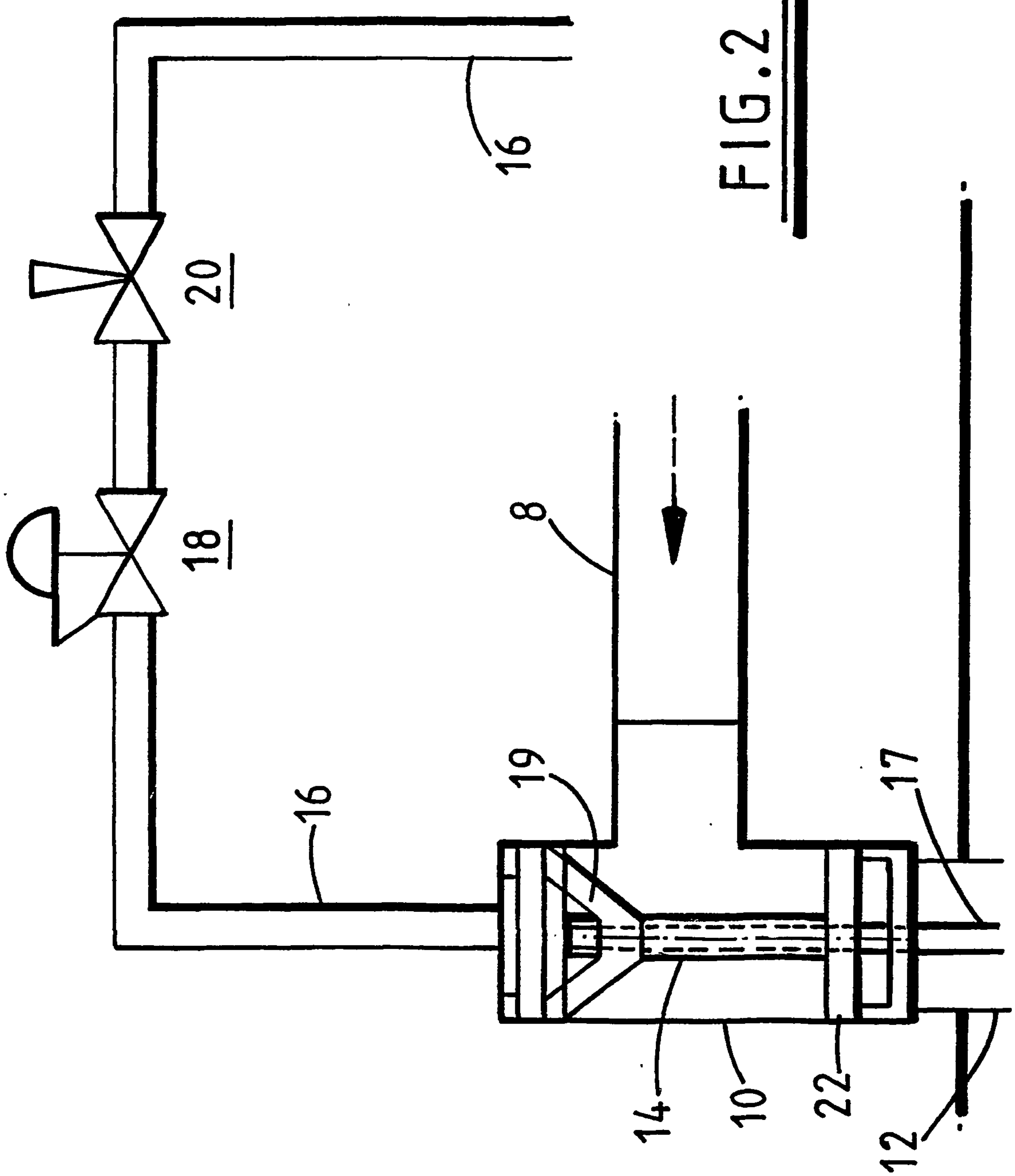

FIG.2

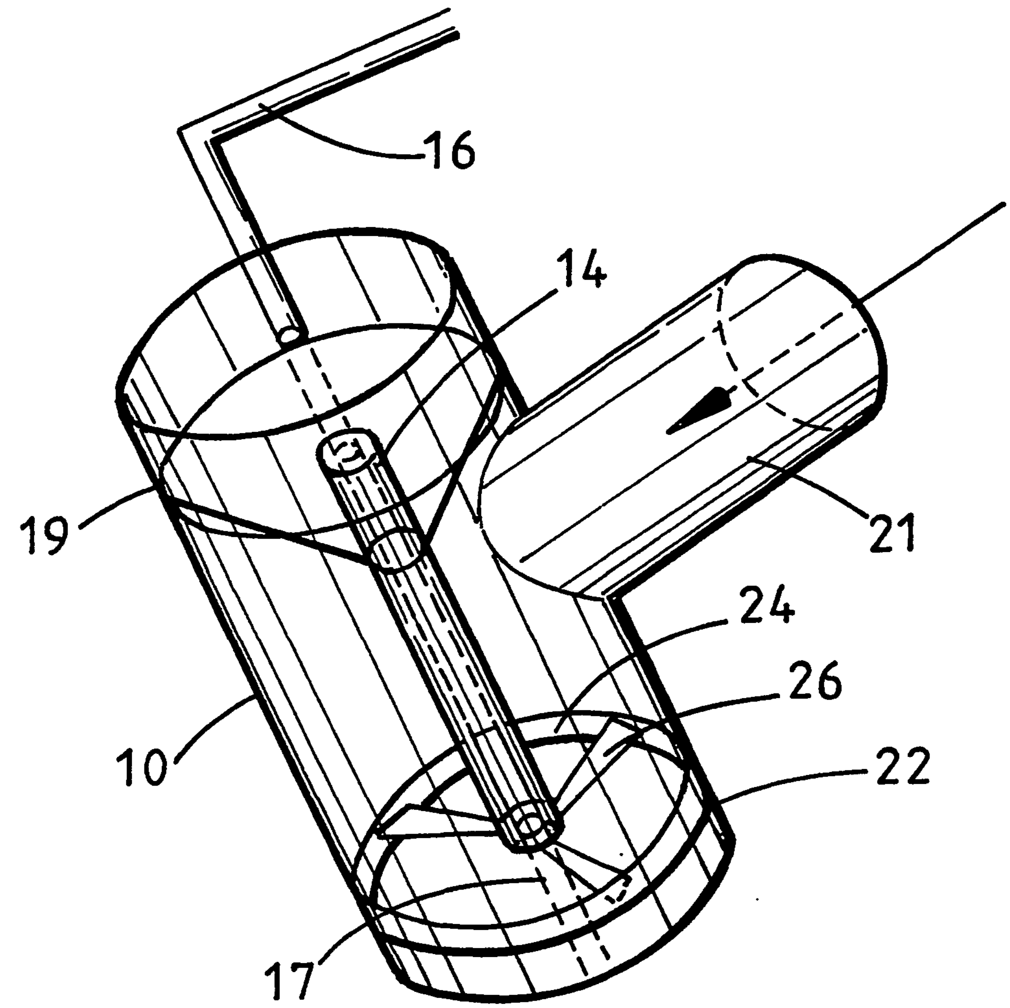

FIG.3

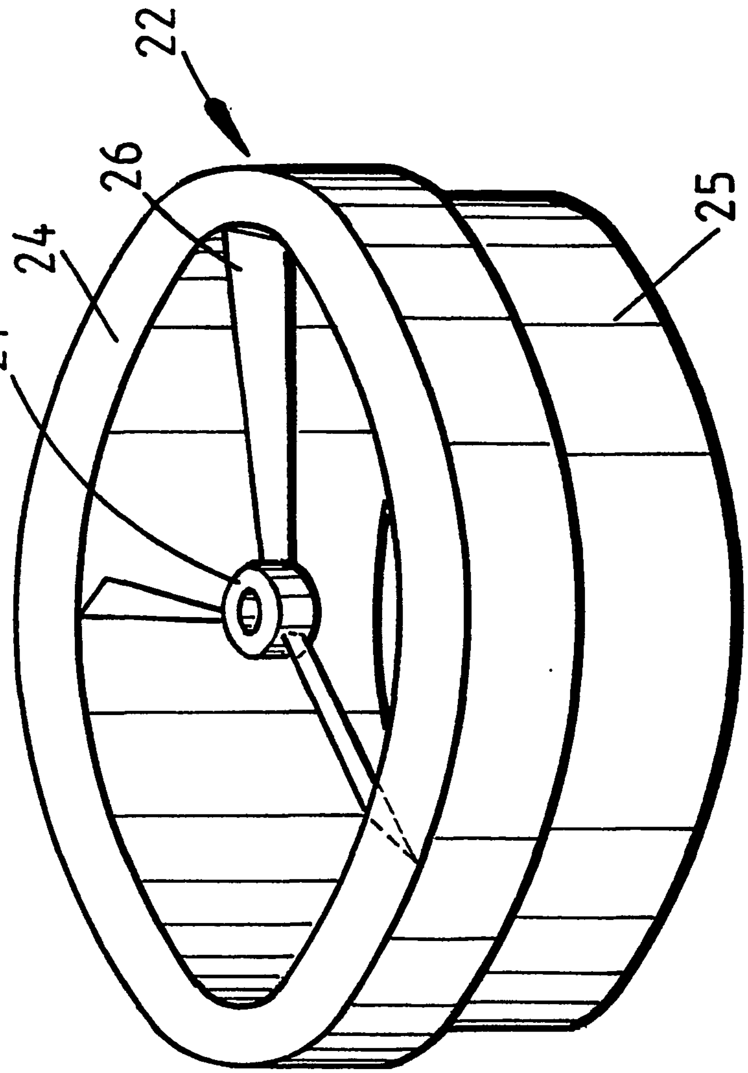

FIG. 4

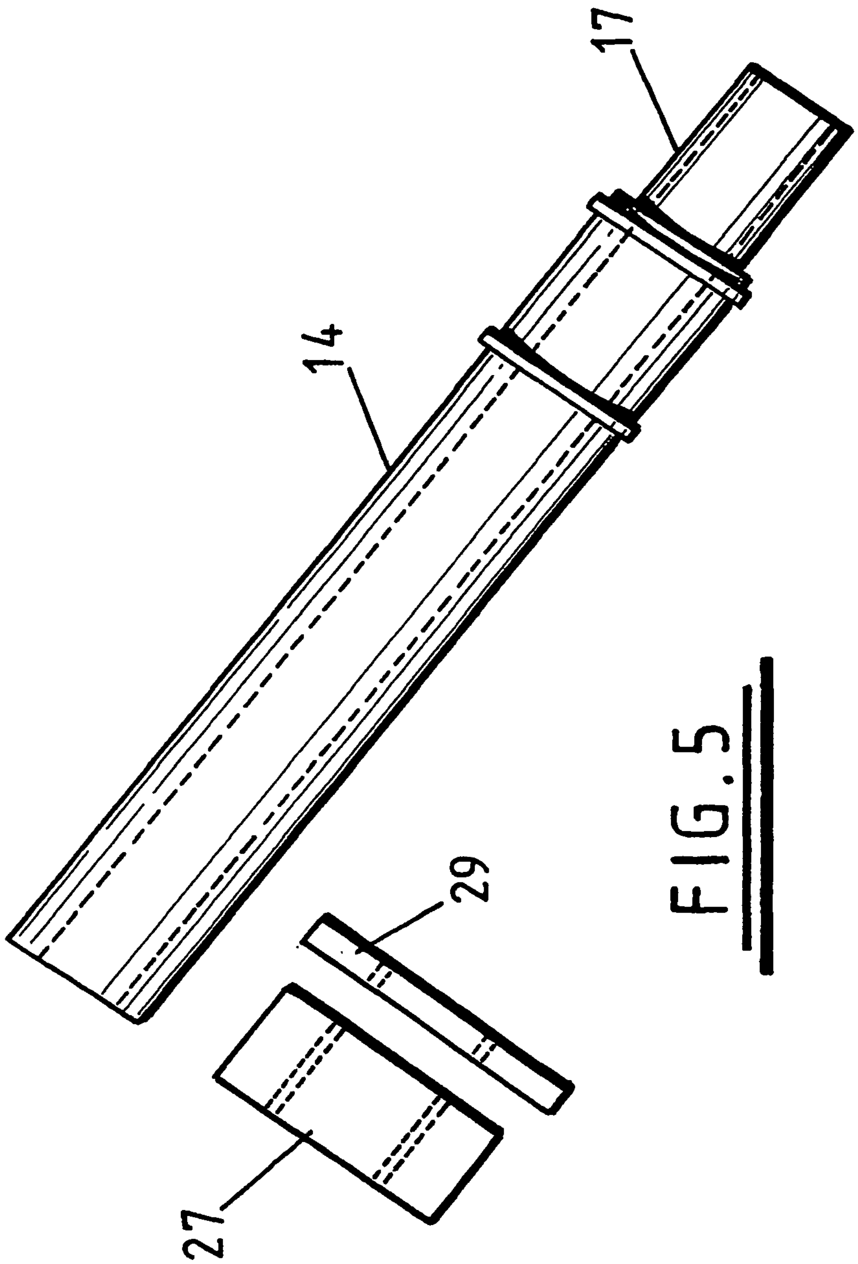

FIG. 5

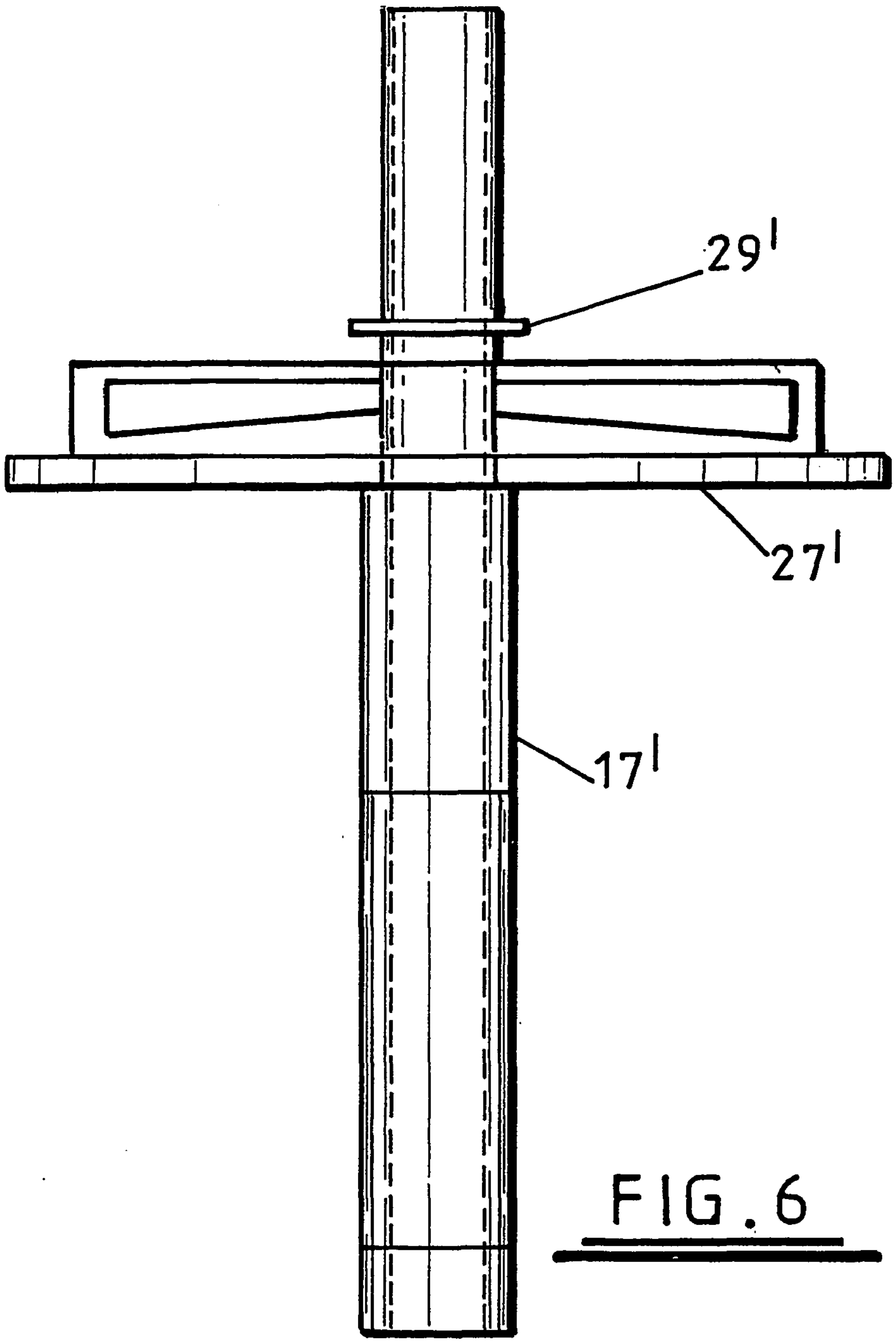

FIG. 6

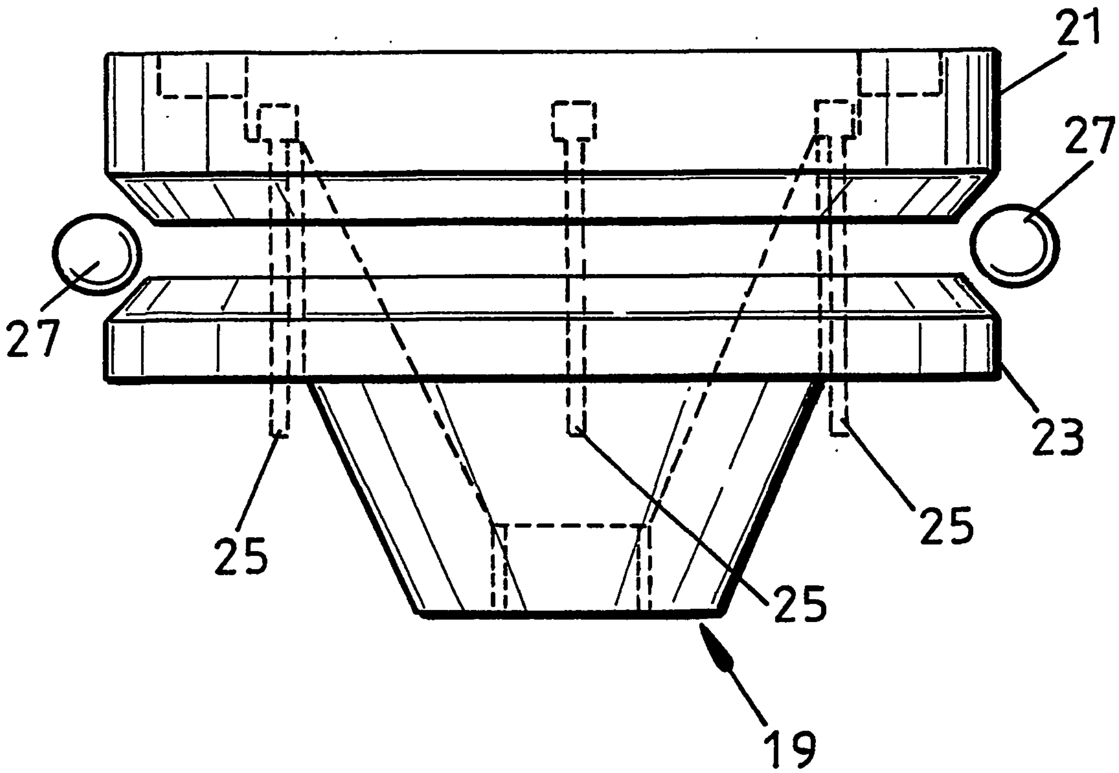

FIG.7

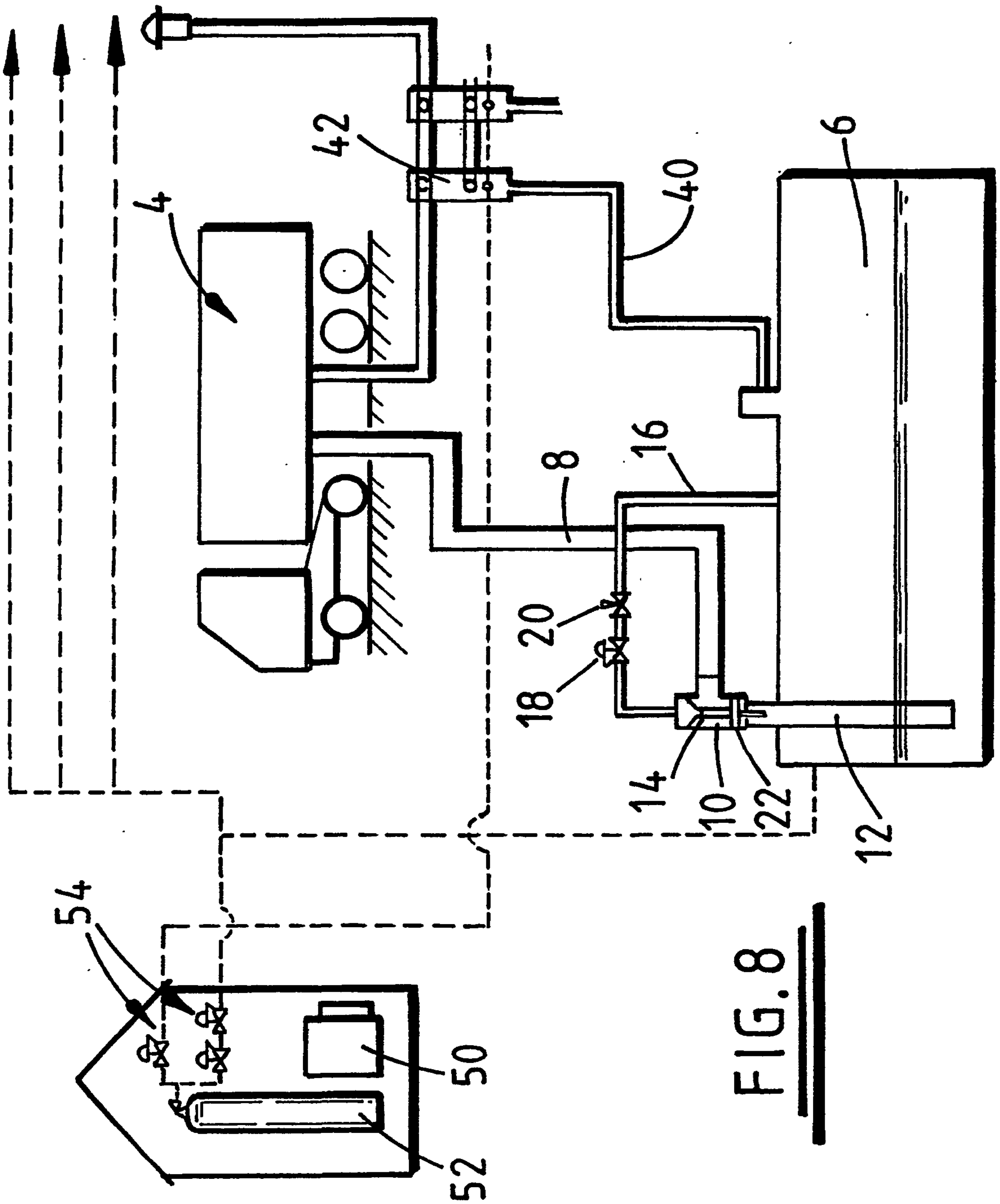

FIG. 8

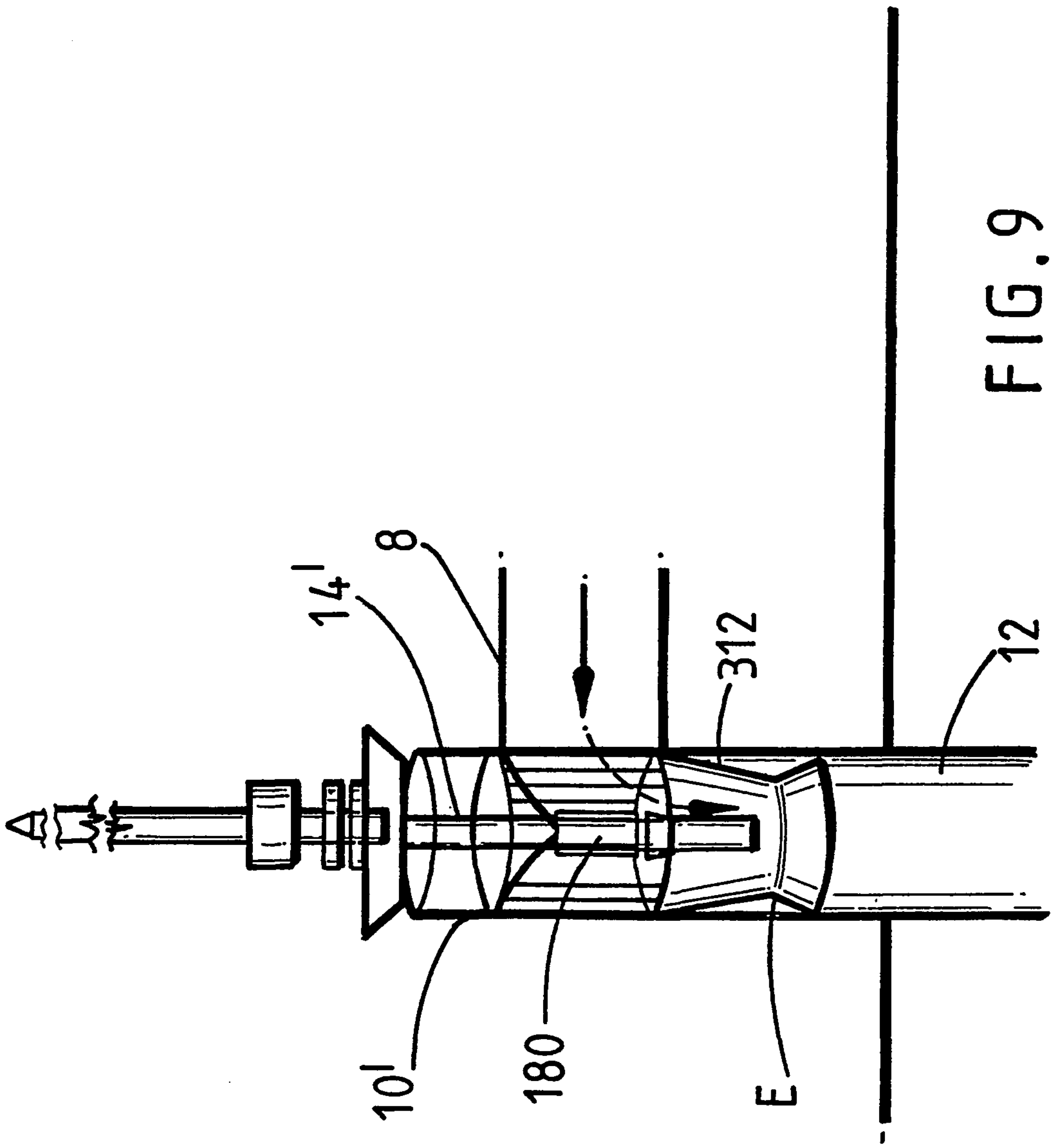

FIG. 9

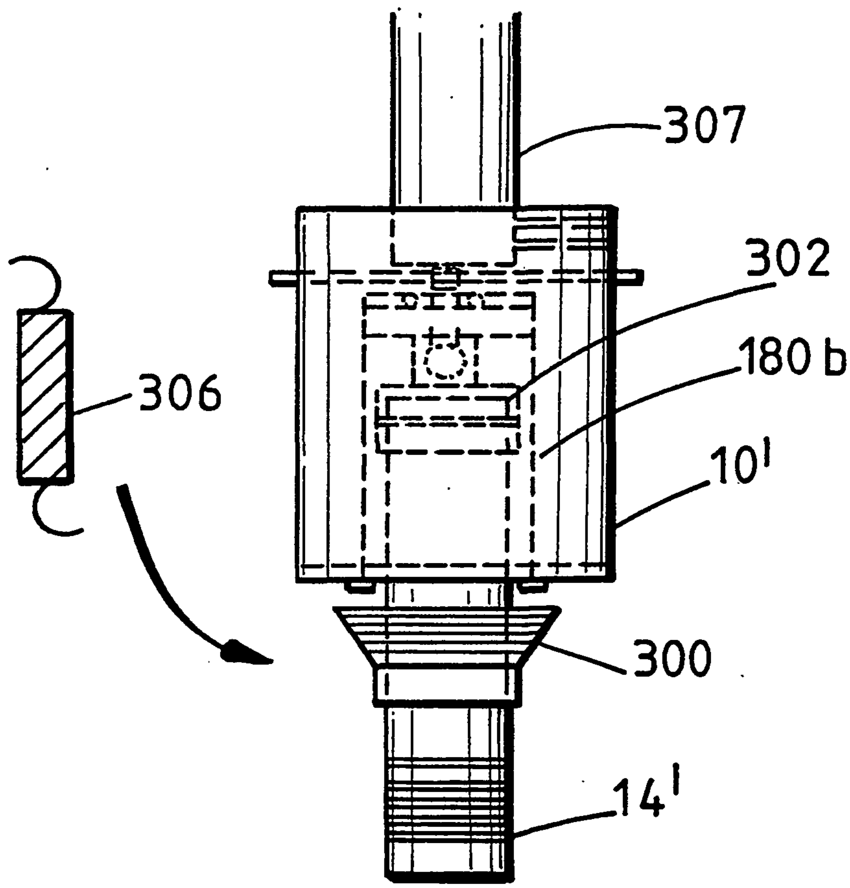

FIG.10a

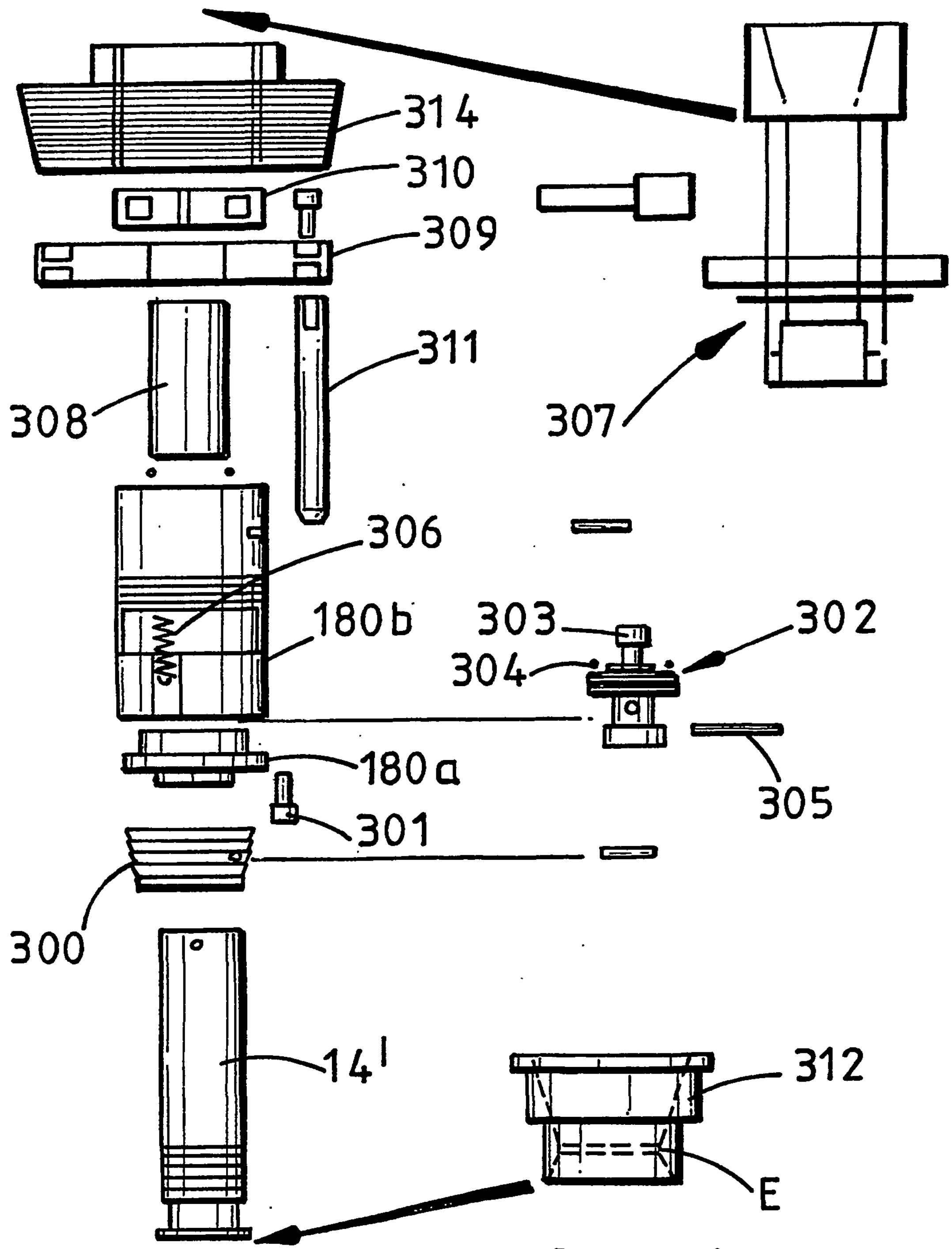
314
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FIG.10b

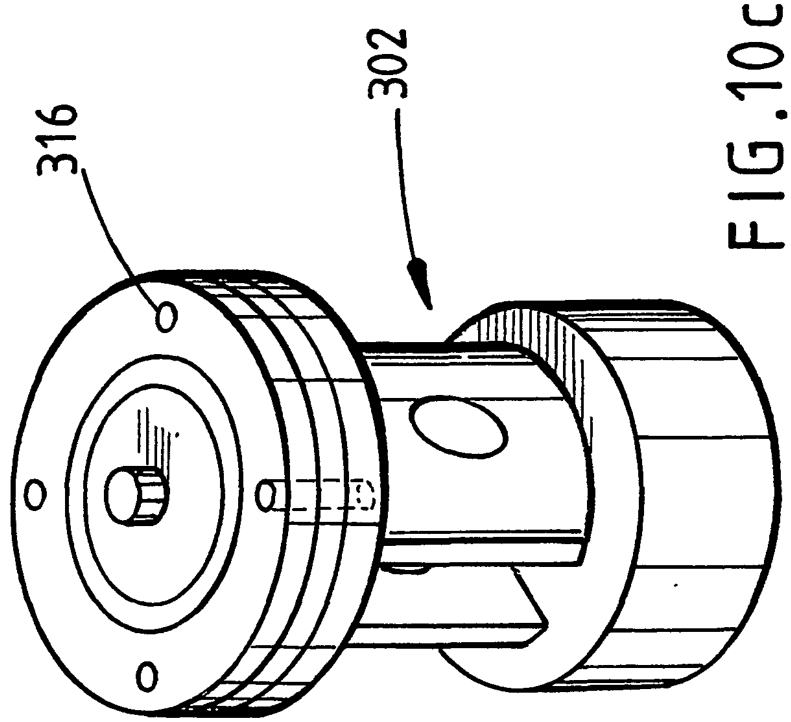

FIG.10c

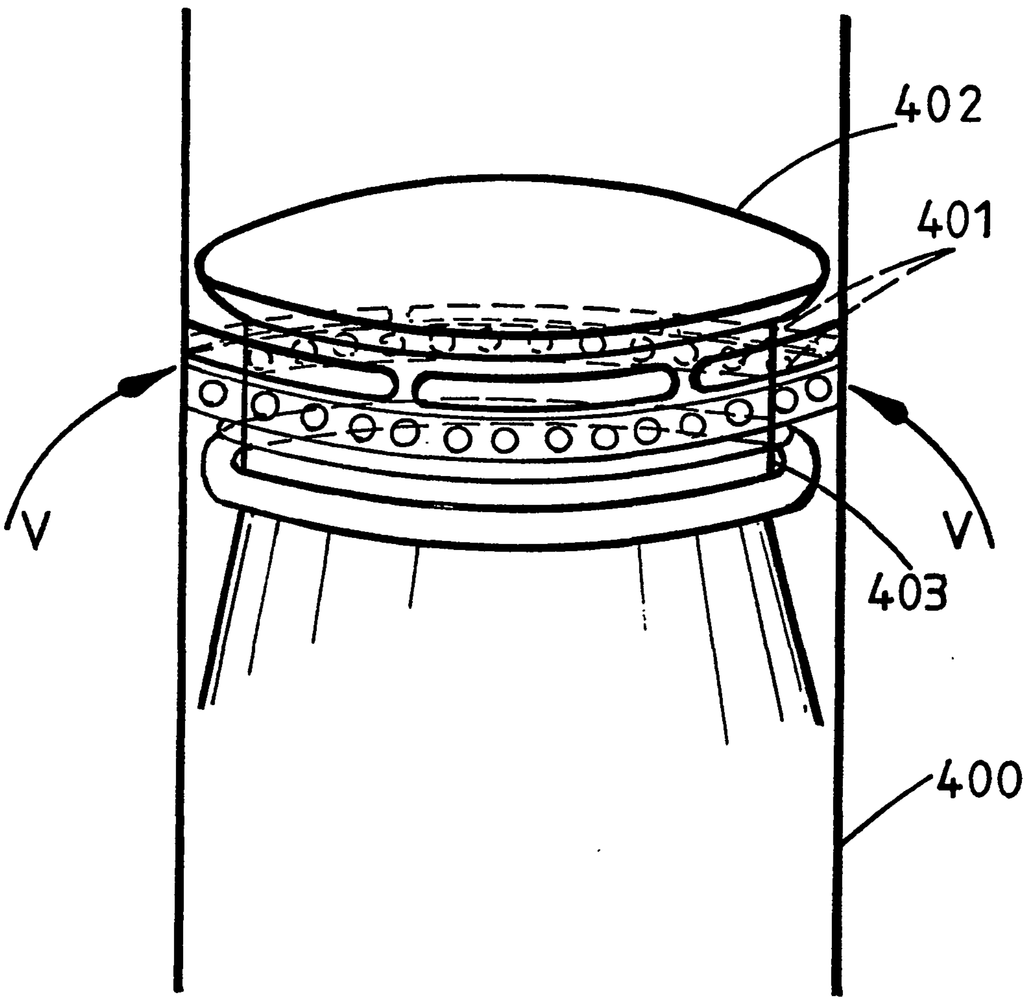

FIG.11

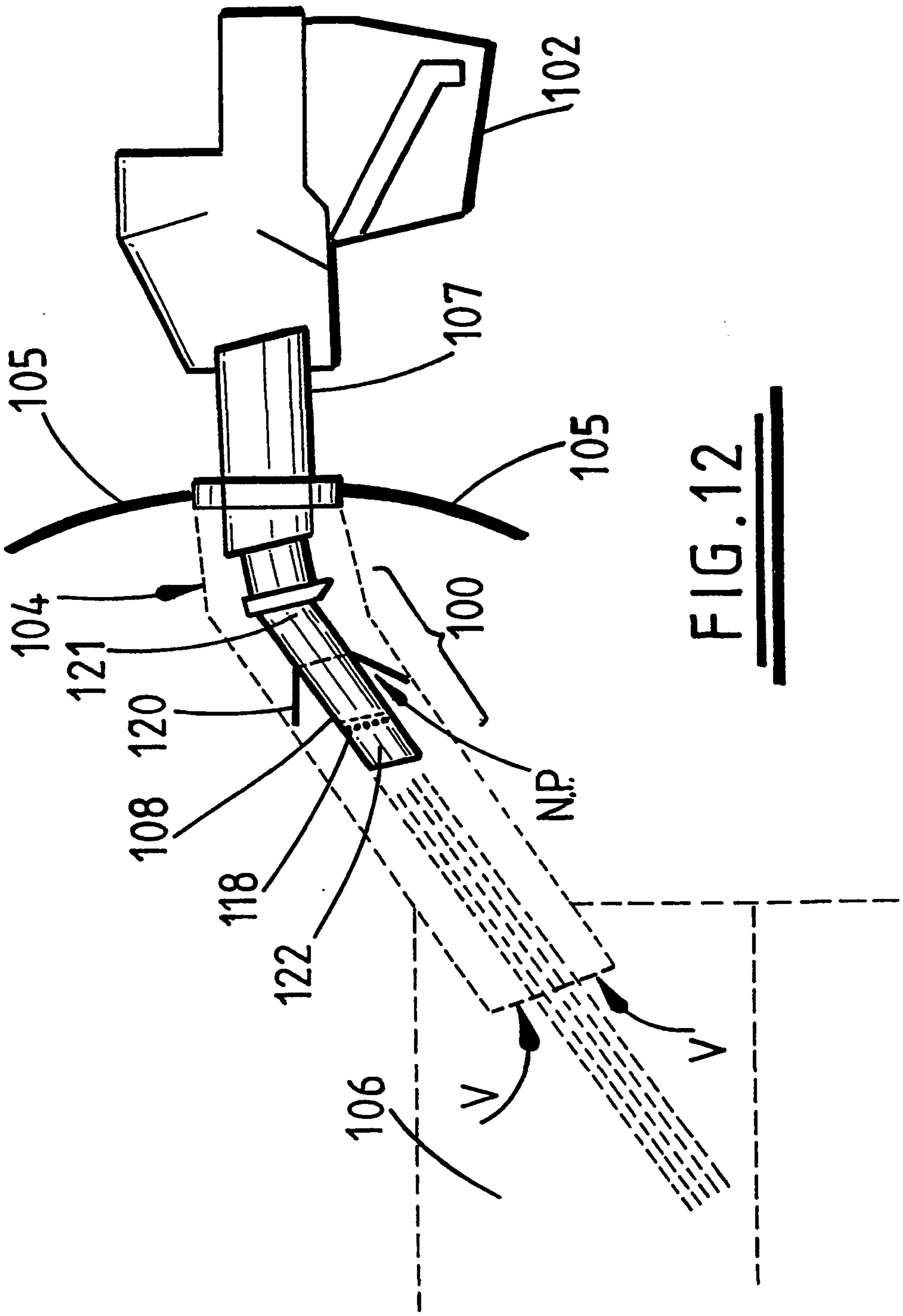

FIG.12

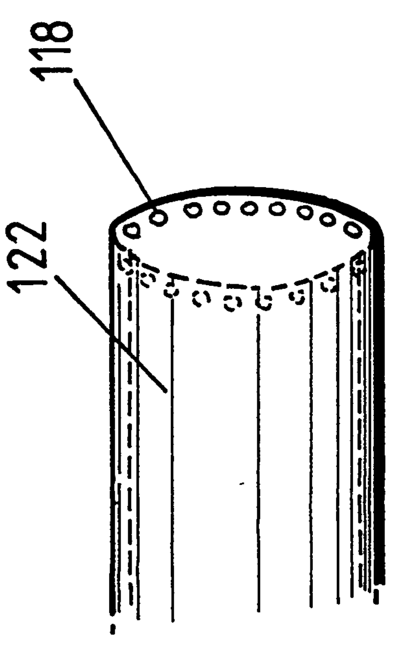

FIG.13a

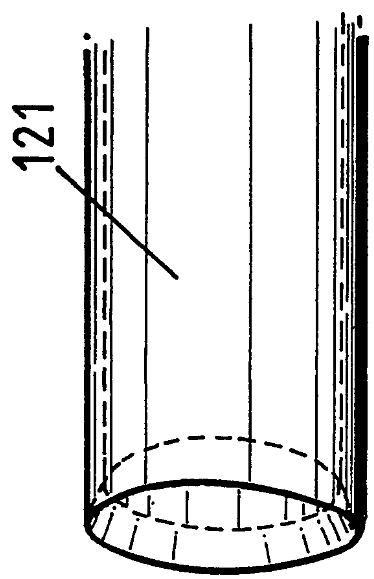

FIG.13b

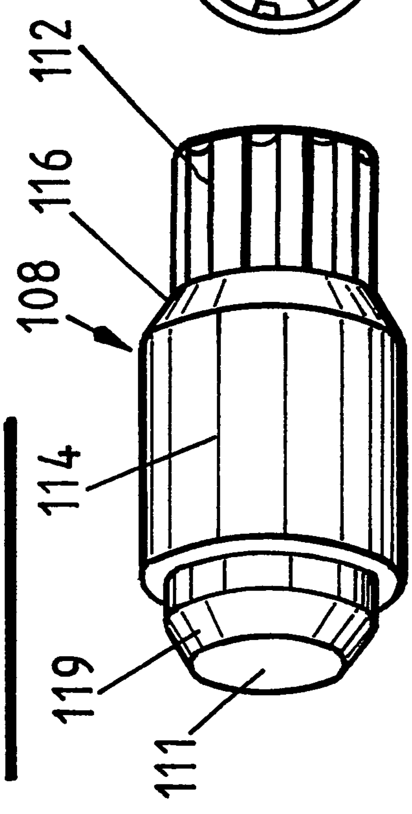

FIG.14a

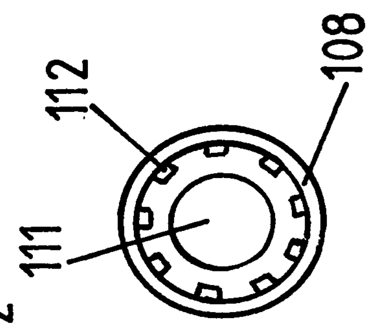

FIG.14b

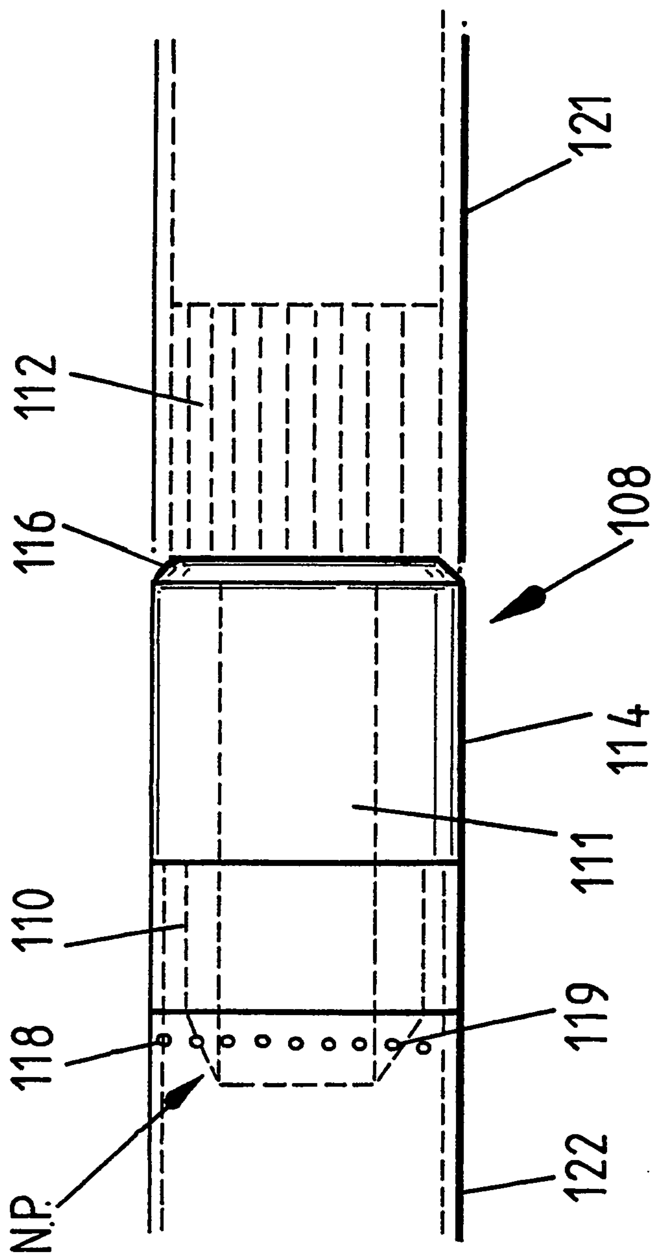

FIG.15

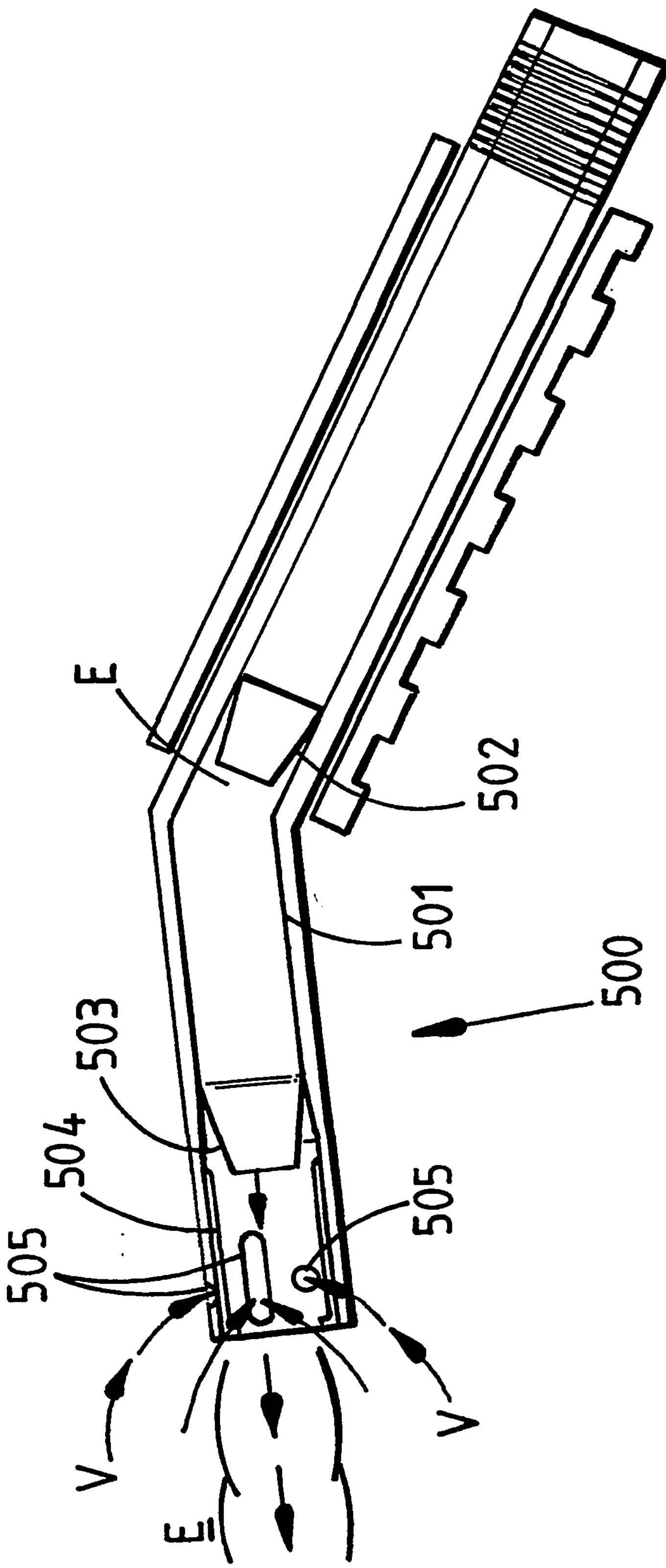

FIG.16

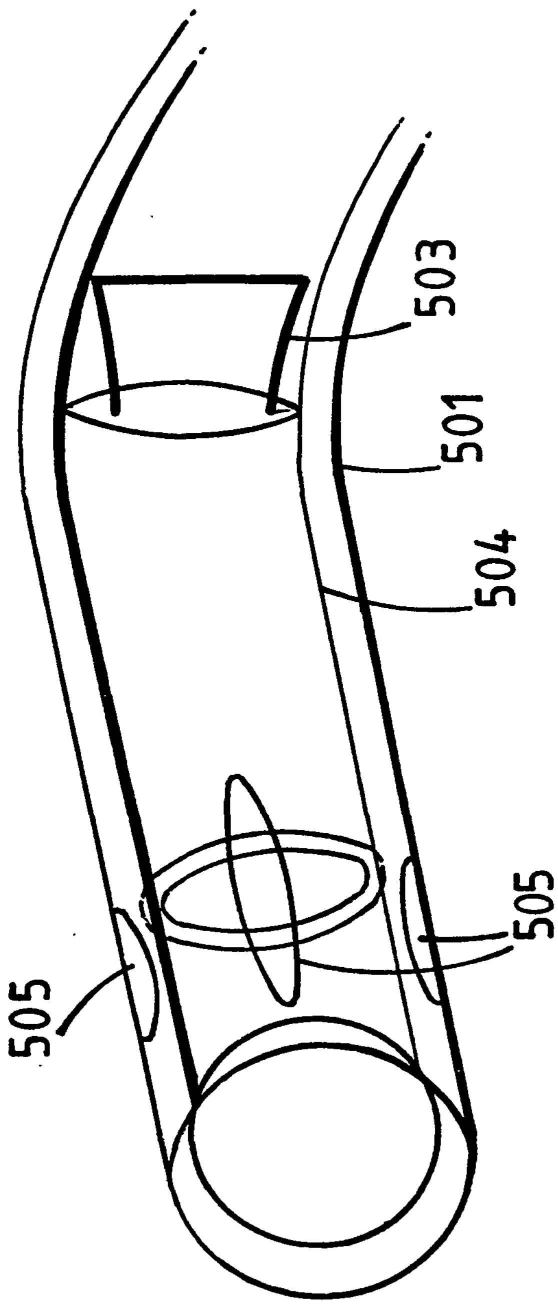

FIG. 17

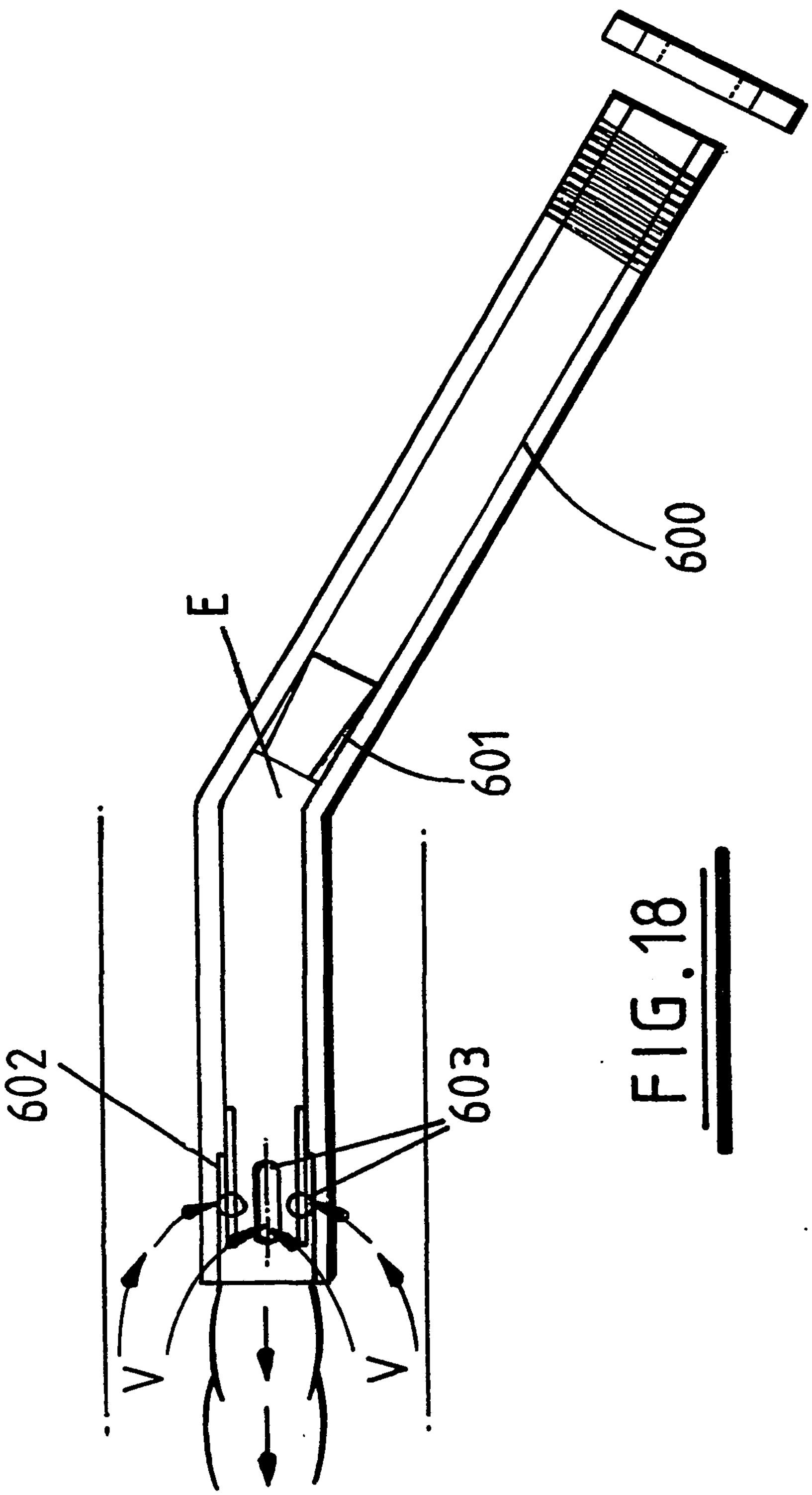

FIG. 18

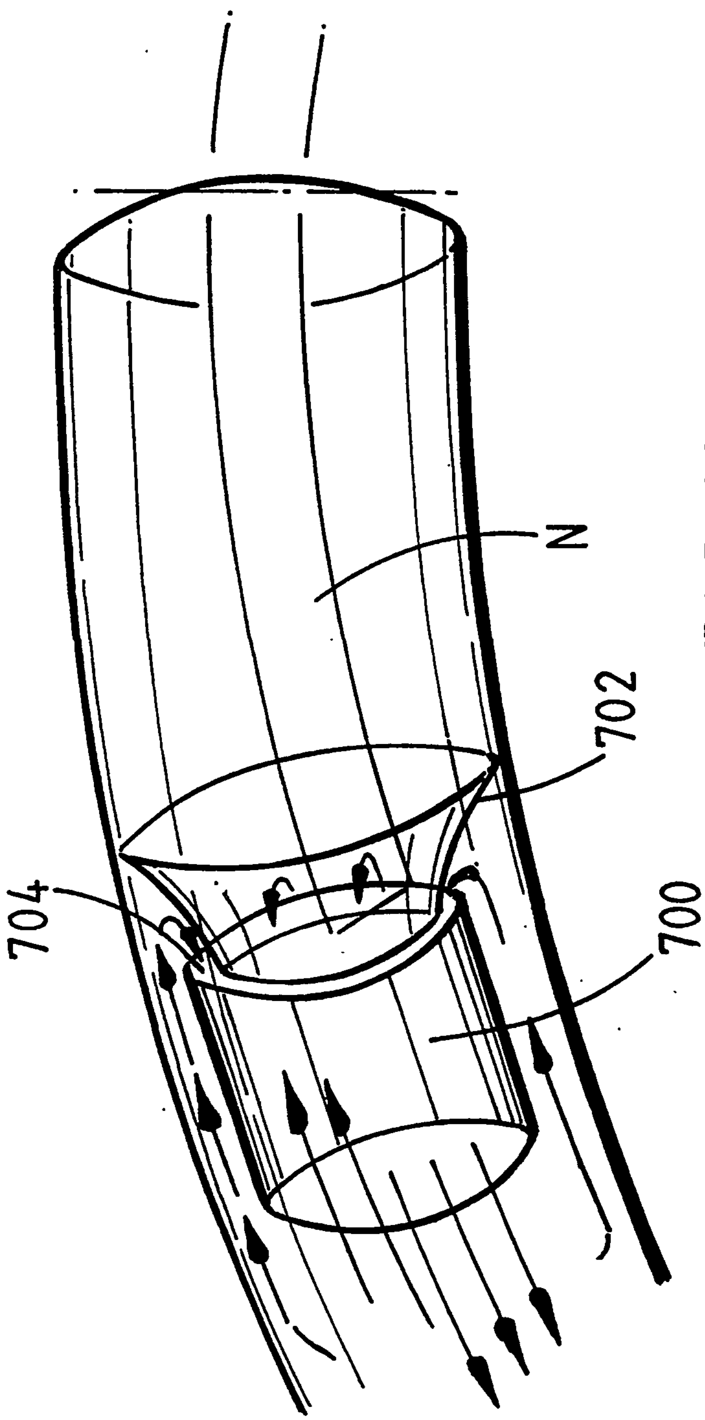

FIG.19

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/05053

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B67D5/04 B65D90/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B67D B60K B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 39 16 691 A (HAYNAL GABOR) 29 November 1990 (1990-11-29) column 1, line 46 -column 2, line 24; figure 1	1-3,5,7, 16,17, 26,30-33
X	JP 2000 159296 A (FUTABA INDUSTRIAL CO LTD) 13 June 2000 (2000-06-13) figures 10,11	1-3,5,6, 8,31-33
X	US 2 072 202 A (FLINCHBAUGH HENRY K) 2 March 1937 (1937-03-02) column 3, line 58 - line 68; figure 1	1-3,5-8, 17,26, 27,30,33
X	DE 11 37 392 B (JOHANN BARENBERG) 27 September 1962 (1962-09-27) column 2, line 16 - line 21; figure 1	1,2,31, 33

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2002	28/02/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schneider, M

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INTERNATIONAL SEARCH REPORT

lonal Application No
PCT/GB 01/05053

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US 2072202	A	02-03-1937	NONE		
DE 1137392	B		NONE		